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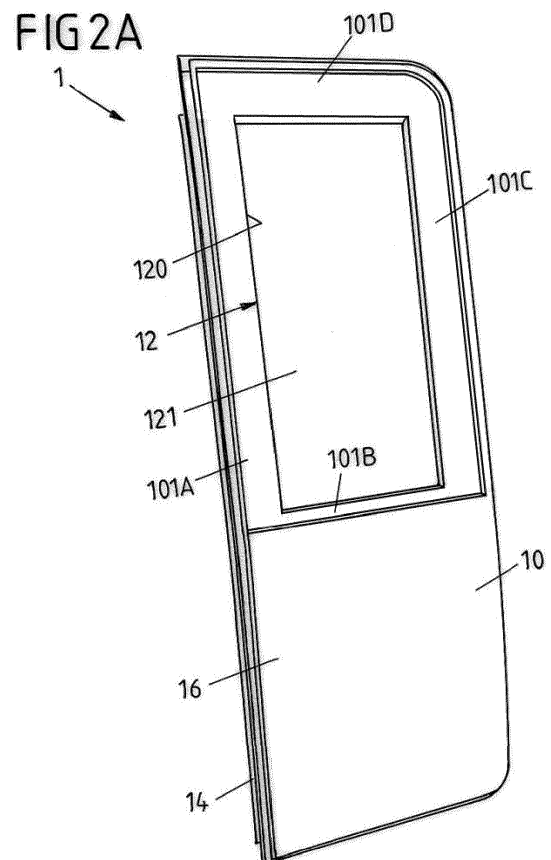
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(54) **Door leaf device for mass transportation vehicles**

(57) The invention relates to a door leaf device being configured and provided for use in a wagon (2) of a mass transportation vehicle, having an outside face (16), an inside face (17), a height and a width and comprising an outer door leaf layer (10; 10') at least partially forming the outside face (16) and an inner door leaf layer (11; 11') at least partially forming the inside face (17), the outer and inner door leaf layers (10, 11; 10', 11') being arranged with respect to one another so as to form an inner space (13) therebetween. It is provided that at least one of the outer and inner door leaf layers (10, 11; 10', 11') substantially extends over the height and/or the width of the door leaf device (1; 1') and is formed in one piece. The invention further relates to a method for the production of a door leaf device.



## Description

**[0001]** The invention relates to a door leaf device for wagons of mass transportation vehicles according to claim 1, to a method for producing a door leaf device for wagons of mass transportation vehicles according to claim 14 and to a wagon according to claim 20.

**[0002]** Mass transportation vehicle doors and in particular door leaf devices of such doors on the one hand have to be robust since they are subject to high stress. On the other hand such doors and door leaf devices have to be as light as possible.

**[0003]** From practice, mass transportation vehicle door leaf devices fulfilling these requirements are known to the applicant, wherein a frame, in particular an aluminum frame or alternatively a stainless steel or steel frame, defining the shape of the door, is attached with an inner and an outer panel. A hollow space between the panels and inside the frame may be, for example, filled with fiber mats for temperature and/or noise isolation. The inner and outer panels often are fastened to the frame by means of gluing, riveting or by welding. Such door leaf devices may have a high weight and/or may have to be produced in a cumbersome procedure.

**[0004]** The object of the invention is to provide an improved door leaf device, in particular a door leaf device for mass transportation vehicles, which is easy to manufacture.

**[0005]** Said object is achieved by a door leaf device having the features of claim 1.

**[0006]** Such a door leaf device, being configured and provided for use in a wagon of a mass transportation vehicle, has an outside face configured to be arranged towards an outside of the wagon and an inside face configured to be arranged towards an inside of the wagon. The door leaf device has a certain height and width and comprises an outer door leaf layer at least partially forming the outside face of the door leaf device and an inner door leaf layer at least partially forming the inside face of the door leaf device. The outer and inner door leaf layers are arranged with respect to one another so as to form an inner space therebetween. It is provided that at least one of the outer and inner door leaf layers substantially extends over the height and/or the width of the door leaf device and is formed in one piece.

**[0007]** Forming a part in one piece which extends substantially over the width and/or height of the door leaf device is based on the idea to form a part which extends over large parts of one of the outer or inner sides of the door leaf device in one single piece in order to reduce the number of parts necessary for the production of the door leaf device. Depending on the material used for the outer and inner door leaf layers, the door leaf device may also be particularly robust as the number of connections between separate parts may be reduced.

**[0008]** The door leaf device may particularly be used in mass transportation vehicles, such as trains, subways, trams, busses, airplanes, cable cars, street cars, etc.;

however, the door leaf device may also be used elsewhere, e.g. for room doors, front doors, balcony doors, and others.

**[0009]** The outer and inner door leaf layers may at least partially provide a contour of the door leaf device. The outer and inner door leaf layers may also at least partially provide the outside and inside surfaces of the door leaf device; however, they may also be at least partially covered, e.g. by a protective layer, a varnish etc. Alternatively or in addition, the outer and inner door leaf layers may serve as a decor, with or without finish or surface treatment.

**[0010]** Because at least one of the outer and inner door leaf layers are formed in one piece and not in a plurality of pieces which would have to be assembled during production of the door leaf device, the production of such a door leaf device may be particularly easy.

**[0011]** The one of the outer and inner door leaf layers which is formed in one piece and substantially extends over the height and/or width of the door leaf device may be made by deep-drawing or thermoforming a planar sheet material. Of course and in particular, both of the outer and inner door leaf layers may be formed by deep-drawing or thermoforming a planar sheet material. However, one or both of the outer and inner door leaf layers may alternatively also be formed in a different procedure, such as extrusion, rolling or injection molding.

**[0012]** At least one of the outer and inner door leaf layers may comprise a polymer, in particular a plastics material, melamine resin, sheet metal or any combination of such materials. In particular one or both of the outer and inner door leaf layers extending over large parts of the outer or inner faces of the door leaf device and being formed in one piece, respectively, may be formed of a plastics material, in particular sheets of a plastics material. Melamine resin may serve for fire protection.

**[0013]** The production of the door leaf device may be further simplified when both the outer door leaf layer and the inner door leaf layer each substantially extend over the height and/or the width of the door leaf device and are formed in each one piece.

**[0014]** The inner space formed between the outer and inner door leaf layers may partially, in particular substantially entirely be filled with a core material. Such core material may serve for providing rigidity and/or stiffness of the door leaf device as it may delimit eventual deformations of the outer and inner door leaf layers, depending on its material properties. Alternatively or additionally, the core material may serve for heat insulation, for noise protection and/or fire protection.

**[0015]** It may be provided that all parts of the door leaf device located on the outside face thereof and serving for forming the inner space which is to be filled with the core material (and which are thus in contact with the core material) are formed in one single piece and form the outer door leaf shell. Alternatively or additionally, it may be provided that all parts of the door leaf device located on the inside face thereof and serve for forming the inner

space which is to be filled with the core material (and which are thus in contact with the core material) are formed in one single piece and form the inner door leaf shell.

**[0016]** The core material may comprise a foam material, such as polyurethane (PU) foam, XPS foam, PVC foam, PET foam, melamine foam, in particular a foam consisting of or comprising melamine resin and/or metal foam. The core material may in particular comprise rigid PU foam with a density of 30 to 300 kg/m<sup>3</sup>, and very particular rigid PU foam with a density of 50 to 100 kg/m<sup>3</sup>. Alternatively or additionally, the core material may comprise melamine resin, glass fibers, one or more fiber-reinforced composites, a honeycomb material and/or one or more rigid foam boards. Depending on their material composition, foam, fiber and honeycomb materials may be very light.

**[0017]** The core material may comprise a first foam material having a first hardness and a second foam material having a second hardness (and/or density and/or rigidity), wherein the first hardness (and/or density and/or rigidity) is different from the second hardness (and/or density and/or rigidity). Of course, the core material may comprise further additional materials, in particular foam materials, each having a hardness being equal, similar or different to the first or second hardness (and/or density and/or rigidity). Alternatively or additionally, the first, second and/or further foam materials may be made of different types of materials, e.g., one foam material could be made of a melamine resin foam while another foam material is made of a PU foam. As an example, the hardness (and/or density and/or rigidity) of the foam material may be adapted to the forces, loads or stress, a certain part of the door leaf device is typically exposed in use. E.g., a section of the core material in (or adjacent to) an area of the door leaf device, which serves for mounting and/or driving the door leaf device may comprise harder foam material than other sections of the core material. Eventually but not necessarily, foam material with a higher hardness (and/or density and/or rigidity) may have a higher specific weight than a foam material with a comparably lower hardness (and/or density and/or rigidity).

**[0018]** The outer and inner door leaf layers as well as the core material may be made of a flame retardant, in particular nonmetallic material. E.g., the core material may be made of melamine resin foam.

**[0019]** The door leaf device may comprise one or more windows, which may be formed by providing cutouts in the outer and inner door leaf layers overlapping each other. The cutouts may be formed by removing material from the outer and/or inner door leaf layers; alternatively, the outer and/or inner door leaf layers may already be formed having cutouts (e.g. by a corresponding injection molding form).

**[0020]** Alternatively or additionally, at least one of the outer and inner door leaf layers, in particular both of the outer and inner door leaf layers, may comprise a transparent (or translucent) material, e.g. a transparent plas-

tics material (or polymer in general), wherein at least a section of the transparent material forms a window of the door leaf device. The transparent material may or may not have a certain color.

**[0021]** In particular at least one transparent section of one of the outer and inner door leaf layers may be aligned with a cutout or with a transparent section of the other one of the outer and inner door leaf layers such that a window is formed through which light may pass. Of course, one or both of the outer and inner door leaf layers may entirely be formed of a transparent material.

**[0022]** Optionally, sections of the outer and/or inner door leaf layers (in particular when being made of a transparent material) may be painted, varnished and/or covered with a foil.

**[0023]** At least the one of the outer and inner door leaf layers, which is formed in one piece and substantially extends over the height and/or width of the door leaf device, may provide one or more edge portions of lateral, upper and/or lower edges of the door leaf device. Such edge portions may extend at an angle, in particular substantially vertical with respect to the outside and/or inside faces of the door leaf device.

**[0024]** Further, at least one of the outer and inner door leaf layers may comprise an inner surface which at least partially faces the inner space between the outer and inner door leaf layers and which is at least partially, e.g. in sections, provided by a polymer material, a plastics material, a resin, epoxy and/or a fiber material such as glass fiber. Such a material may be provided to (sections of) the inner surfaces of the outer and inner door leaf layers e.g. by coating and/or by working it into the inner surface.

**[0025]** The outer and/or inner door leaf layers may form partial sections of the external surface of the door leaf device. In particular, the partial sections of the external surface of the door leaf device may be located at the outside and/or inside faces of the door leaf device. Further, the outer and/or inner door leaf layers may form substantially the entire external surface of the door leaf device (which is not covered e.g. by sealing elements, windows, etc.). Particularly, the outer and/or inner door leaf layers may form an externally visible surface structure and/or provide an externally visible color of at least partial sections of the surface of the door leaf device, in particular at the outside and/or inside faces of the door leaf device. In these cases, coloring (e.g. by means of a varnish) the external surfaces of the door leaf device may be obsolete, what may further simplify the production of the door leaf device.

**[0026]** Alternatively or additionally, the outer and/or inner door leaf layers may (in sections or entirely) be colored through with a certain color (herein, the expression color is meant as including gray shades and black) or with several colors. In particular, the outer and/or inner door leaf layers may be made of a fully tinted material. The outer and/or inner door leaf layers may or may not be varnished. An uncoated, unvarnished, colored-

through outer/inner door leaf layer can be particularly tolerant with respect to damages such as scratches or abrasions, since the surface color is the same as the color of deeper material sections and scratches or abrasions therefore do not expose a material color different to the surface color which would be clearly visible.

**[0027]** The object of the invention is also achieved by a method for the production of a door leaf device having the features of claim 14.

**[0028]** According to the method for the production of a door leaf device being configured and provided for use in a wagon of a mass transportation vehicle, wherein the door leaf device has an outside face, an inside face, a height and a width, the following steps are performed:

- providing an outer door leaf layer for at least partially forming the outside face and an inner door leaf layer for at least partially forming the inside face and
- arranging the outer and inner door leaf layers with respect to one another so as to form an inner space therebetween.

**[0029]** Therein, it is provided to perform the preceding step of:

- forming at least one of the outer and inner door leaf layers in one piece and such that it substantially extends over the height and/or the width of the door leaf device.

**[0030]** Because, according to the method, at least one of the outer and inner door leaf layers are formed in one piece and not in a plurality of pieces which would have to be assembled during production of the door leaf device, the production of such a door leaf device may be particularly easy.

**[0031]** Forming the at least at least one of the outer and inner door leaf layers in one piece and such that it substantially extends over the height and/or the width of the door leaf device may be carried out by deep-drawing or thermoforming a planar sheet material.

**[0032]** After arranging the outer and inner door leaf layers with respect to one another so as to form an inner space therebetween, a foam material may be introduced, injected, pressed or poured into the inner space between the outer and inner door leaf layers in a liquid form and then cured inside the inner space. Alternatively, the foam material may also be cured first and then be introduced in the inner space between the outer and inner door leaf layers.

**[0033]** Before or after arranging the outer and inner door leaf layers with respect to one another so as to form an inner space therebetween and before or after introducing the foam material into the inner space between the outer and inner door leaf layers, material of at least one of the outer and inner door leaf layers may be removed by cutting, milling and/or drilling, for example in

order to provide holes for receiving fastening elements, providing recesses for engagement with further components of the door leaf device, for providing cutouts for one or more windows, etc.

5 **[0034]** According to the method, optionally a window pane may be arranged and secured at a window opening in the door leaf device. Such a window opening may be formed by providing aligned cutouts in the outer and inner door leaf layers, e.g. by previously removing material.

10 **[0035]** The method may be adapted for the production of a door leaf device according to any aspect or embodiment described herein.

**[0036]** According to another aspect of the invention, a door leaf device being configured and provided for use in a wagon of a mass transportation vehicle is provided, wherein the door leaf device is produced according to any embodiment or combination of embodiments of the method described herein.

15 **[0037]** According to another aspect of the invention, a wagon is provided, comprising at least one door leaf device according to any embodiment and aspect described herein or according to any combination of aspects and/or embodiments described herein and/or according to any embodiment or combination of embodiments of the method described herein.

20 **[0038]** The invention will be explained in more detail in the following description of exemplary embodiments with reference to the accompanying figures, wherein:

30 Fig. 1 shows a mass transportation vehicle in a perspective view, comprising several sliding plug doors,

Fig. 2A shows an outside face of a door leaf device of the wagon shown in Fig. 1,

35 Fig. 2B shows an inside face of the door leaf device of Fig. 2A,

40 Fig. 3 shows a part of the door leaf device of Figs. 2A and 2B, cut open along plane A-A shown in Fig. 2B,

45 Fig. 4 shows a part of the door leaf device of Figs. 2A and 2B, cut open along plane B-B shown in Fig. 2B,

Figs. 5A, 5B show forming tools for the production of an outer and an inner door leaf shell of the door leaf device of Fig. 2A and 2B in perspective views,

Fig. 6A shows the forming tool of Fig. 5A in a cross-sectional view,

55 Fig. 6B shows the forming tool of Fig. 5B in a cross-sectional view,

- Fig. 7 shows a foaming tool for introducing a foam into an inner space between the outer and inner door leaf layers of the door leaf device of Fig. 2A and 2B,
- Fig. 8 shows a milling fixture to fix a door leaf device for milling and
- Figs 9A, 9B show another embodiment of a door leaf device.

**[0039]** Fig. 1 shows a wagon 2 of a mass transportation vehicle comprising a wagon body 20, wagon windows 21 and several doors 22. The doors 22 of the wagon 2 each comprise two door leaf devices 1 with each one door window 12. The door leaf devices 1 will be described in greater detail with reference to the following figures.

**[0040]** The wagon 2 of Fig. 1 is a wagon 2 of a mass transportation vehicle, in particular of a metro train, and serves as an example for all other mass transportation vehicles, such as railway trains, busses, airplanes, cable cars, street cars and others and both for mass transportation vehicles having one wagon only and mass transportation vehicles having more than one wagon.

**[0041]** Mass transportation vehicles, such as the mass transportation vehicle having a wagon 2 as shown in Fig. 1, are boarded and alighted through doors. Often, sliding plug doors are used for such vehicles, such as the doors 22 in Fig. 1. However, the doors 22 may also be designed as other types of doors, such as e.g. plug doors, swing doors, slide doors etc.

**[0042]** There are wagons that only comprise one door. However, usually, wagons of mass transportation vehicles comprise more than one door. For example, a wagon may comprise two, three, four or more doors on either side of the wagon. Often, doors of wagons of mass transportation vehicles are constructed as double doors. Eventually, the wagons may comprise one or more additional doors for a driver. In some wagons, there are also doors inside the wagon. In some types of mass transportation vehicles, one or more doors connect each two wagons of the vehicles. For all such doors, doors 22 comprising at least one door leaf device 1 as described herein may be used. In the example shown in Fig. 1, the wagon 2 comprises three passenger doors 22 on both lateral sides of the wagon body 20, each including two door leaf devices 1, and a door 23 for a driver of the wagon 2, including one door leaf device similar to the door leaf devices 1 of the passenger doors 22 but of a different geometry.

**[0043]** Figs. 2A and 2B show a door leaf device 1 of a door 22 of the wagon 2 of Fig. 1, wherein Fig. 2A shows a perspective view of the outside face 16 of the door leaf device 1 and Fig. 2B shows a perspective view of the inside face 17 of the door leaf device 1.

**[0044]** The door leaf device 1 has a substantially flat overall shape and has a certain width and height which correspond to the horizontal and vertical extensions, re-

spectively, of the door leaf device 1 being in use, i.e. when being installed in a wagon such as the wagon 2 according to Fig. 1.

**[0045]** Large parts of the outside face 16 of the door leaf device 1 are formed by an outer door leaf layer presently being formed as an outer door leaf shell 10, see Fig. 2A. Similarly, large parts of the inside face 17 of the door leaf device 1 are formed by an inner door leaf layer presently being formed as an inner door leaf shell 11, see Fig. 2B. The outer and inner door leaf shells 10, 11 each substantially extend over the height and the width of the door leaf device 1. Both the outer and inner door leaf shells 10, 11 each are formed in one piece from one piece of material. The production of the outer and inner door leaf shells 10, 11 will be described in more detail with reference to the following figures.

**[0046]** A window 12 is provided in the door leaf device 1, comprising a window pane 121 extending over a window opening 120 provided by corresponding cutouts in the outer and inner door leaf shells 10, 11 having the same shape and being aligned to one another such as to allow for a clear view through the window 12. Presently, the window pane 121 is mounted on the door leaf device 1 on its outside face 16 and rests on corresponding abutment surfaces 101A-101D forming an rectangle on an upper part of the outer door leaf shell 10 and being recessed from adjacent parts of the outer door leaf shell 10 to an extent corresponding to the thickness of the window pane 121 to form an even outer surface 16. For a secure connection, the window pane 121 may for example be adhered to the abutment surfaces 101A-101D.

**[0047]** Below its window 12, the door leaf device 1 is slightly bent such as to form a slightly convex overall shape as seen in direction on the outside face 10. Of course, the door leaf device 1 could alternatively also be formed flat or have a more complicated shape. Moreover, also various other forms are conceivable and the form of the door leaf device 1 may be adapted e.g. to the inner and/or outer shape of a wall of a wagon.

**[0048]** Several seals 14 are arranged at lateral edges of the door leaf device 1 for providing a tight closure of the door in which the door leaf device 1 is or is to be mounted.

**[0049]** Figs 2A and 2B show a simplified door leaf device 1 where various parts that such door leaf device 1 may comprise are not shown. In particular, such a door leaf device 1 may comprise guiding devices, e.g. at upper and lower portions of the door leaf device, for a guiding of the door leaf device 1 when being displaced with respect to the wagon 2 between an opened and a closed position, connecting elements for a connection of the door leaf device 1 with other parts of the wagon 2, such as parts of a door drive mechanism, control elements for controlling an opening and/or closure of the door leaf device 1, signs etc.

**[0050]** The outer and/or inner door leaf shells 10, 11 serve to define parts of the contour of the door leaf device 1 and may also at least partially form the surface of the

door leaf device 1. In the present example, the outer door leaf shell 10 substantially provides those parts of the surface on the outside face 16 of the door leaf device 1, which are not covered by the window pane 12. Correspondingly, the inner door leaf shell 11 substantially provides those parts of the surface on the inside face 17 of the door leaf device 1, which are not covered by the window pane 12. In other words, the outer and inner door leaf shells 10, 11 substantially provide the opaque parts of the surfaces of the outside and inside faces 16, 17 of the door leaf device 1 (for the case that the outer and inner door leaf shells 10, 11 are not formed by a transparent material).

**[0051]** Of course, the outer and inner door leaf shells 10, 11 may be at least partially covered, e.g. by a cover layer, by a varnish, by a protection etc.

**[0052]** The outer and/or inner door leaf shells 10, 11 may furthermore serve for or contribute to the structural stability of the door leaf device 1. In particular, depending on the material and its thickness, it may be possible to omit a heavy frame structure in the door leaf device.

**[0053]** It is also possible to form the door leaf device 1 without any window 12, i.e., by opaque parts only. Alternatively, the window 12 may also be formed such as to extend over a larger part of the outside and inside faces 16, 17 of the door leaf device 1 such that the outer and inner door leaf shells form a shape similar to a frame for the window. Alternatively or additionally, the door leaf device 1 may also comprise more than one window, e.g. two windows or three windows. Furthermore, the window pane 121 (and window panes of the door leaf device 1 in general) may also be mounted on the window opening 120 on the inside face 17 of the door leaf device 1. Alternatively, the window pane 121 may also be inserted in slots provided on lateral side edges of the window opening 120 instead of being mounted on the abutment surfaces 101A-101D shown in Fig. 2A.

**[0054]** As an example, the door leaf device 1 may be formed with a height of about 2100 mm, a width of about 810 mm and extend in a third direction vertical to the height and width directions by about 110 mm.

**[0055]** Fig. 3 shows a section of the door leaf device 1 of Figs. 2A and 2B, being cut open along a plane A-A indicated in Fig. 2B, in a perspective view.

**[0056]** As can be seen from Fig. 3, sections of the outer door leaf shell 10 and the inner door leaf shell 11 are substantially arranged in parallel to each other and spaced apart from each other, such that an inner space 13 between the outer and inner door leaf shells 10, 11 is formed.

**[0057]** In the example of the door leaf device 1 shown in Figs. 2A-3 (as well as the following Fig. 4 described below), the inner space 13 is substantially completely filled with a foam material, in particular with a rigid foam material, forming a core material in the form of a foam layer 15. The foam layer 15 is made of polyurethane (PU) foam, since such foam may be light, inexpensive and robust. The structural stability of the door leaf device 1

may be provided by the outer and inner door leaf shells 10, 11 in conjunction with the foam layer 15. The foam layer 15 may optionally be formed of different materials, e.g. different foam materials having different properties (e.g. specific weight, hardness, rigidity, etc.) or a foam material and another material.

**[0058]** On the lateral edges of the door leaf device 1 seals 14 are provided. The seals 14 engage in recesses formed by cutouts 150A, 150B in the foam layer 15 arranged at gaps 18A, 18B between the lateral edges 102A, 102B of the outer door leaf shell 10 and lateral edges 111 A, 111 B of the inner door leaf shell 11. The seals 14 may be positively held in said recesses and/or adhered thereto. The lateral edges 102A, 102B, 111A, 111 B of the outer and inner door leaf shells 10, 11 protrude at substantially vertical angles from the planes of the outer and inner door leaf shells 10, 11 forming the outside and inside faces 16, 17 of the door leaf device 1. The upper and lower edges of the outer and inner door leaf shells 10, 11 (not visible in Fig. 3) could be designed correspondingly. Therefore, no additional parts have to be mounted at the edges of the door leaf device 1.

**[0059]** As described above, the foam layer 15 is made of polyurethane (PU) foam. Alternatively or additionally, the foam layer 15 may also comprise another rigid foam material as other synthetic foam or metal foam. For example, the foam layer 15 may also comprise XPS foam, PVC foam and/or PET foam or any other suitable material. The foam layer 15 may in particular comprise rigid PU foam with a density of 30 to 300 kg/m<sup>3</sup>, and very particular rigid PU foam with a density of 50 to 100 kg/m<sup>3</sup>.

**[0060]** In addition or as an alternative, the inner space 13 can also be partly filled with another suitable material having the required physical properties, in particular with respect to rigidity, acoustics and durability, e.g. glass fibers, a fiber-reinforced composite and/or a honeycomb material. In particular, the inner space 13 may also be filled with a combination of different foam materials or a combination of one or more foam materials with one or more other materials, e.g. a combination of PU foam with glass fibers, fiber-reinforced composites, honeycomb materials and/or rigid foam boards.

**[0061]** It is also possible to only partially fill the inner space 13 with the foam layer 15 or other material such that parts of the inner space 13 remain empty.

**[0062]** Fig. 4 shows a section of the door leaf device 1 of Figs. 2A and 2B, being cut open along a plane B-B indicated in Fig. 2B, in a perspective view.

**[0063]** In this part of the outer and inner door leaf shells 10, 11, serving as a frame for the door window 12 and comprising the abutment surfaces 101 A, 101 C on the outer door leaf shell 10, two separate compartments 130A, 130B of the inner space 13 are formed and filled by the foam layer 15.

**[0064]** The window opening 120 is formed by aligned cutouts 100A, 110A in the outer and inner door leaf shells 10, 11, respectively, as will be described in greater detail with reference to the following figures. Dashed lines in-

dicating where material of the outer and inner door leaf shells 10, 11 has been removed for forming the window opening 120.

**[0065]** Concerning the seals 14 and their attachment to the door leaf device 1 and details of the foam layer 15 reference is made to the corresponding description relating to Fig. 3.

**[0066]** Turning now to Figs. 5A to 6B, the production of the outer and inner door leaf shells 10, 11 will be described.

**[0067]** Fig. 5A shows a perspective view of a forming tool 30 for the production of outer door leaf shells 10. Correspondingly, Fig. 5B shows a perspective view of a forming tool 31 for the production of inner door leaf shells 11.

**[0068]** The forming tools 30, 31 each comprise a base 300, 310 and a form block 301, 311 arranged on the respective base 300, 310. The form blocks 301, 311 each provide a positive form 305, 315 which correspond to the shape of the outer and inner door leaf shells 10, 11, respectively.

**[0069]** When the forming tools 30, 31 are arranged on a level surface, the positive forms 305, 315 vertically project on an upper face of the form blocks 301, 311, wherein said upper faces serve as form areas 302, 312. The size of the form areas 302, 312 depend on the height and width of the door leaf device 1 and thus on the size of the outer and inner door leaf shells 10, 11, wherein the form areas 302, 312 are dimensioned such that a flat surface of the form areas 302, 312 each encompasses the positive forms 305, 315.

**[0070]** As an example, the size of the form areas 302, 312 may be about 2250 mm in length and about 950 mm in width, wherein the lengths of the form areas 302, 312 result from the heights of the outer and inner door leaf shells 10, 11, respectively, being produced by the forming tools 30, 31 and the widths of the form areas 302, 312 result from their widths.

**[0071]** The forming tools 30, 31 may serve for thermoforming or deep-drawing sheet material, e.g. sheets of a plastics material as plastic foils (or sheets of a polymer), sheet metal or others.

**[0072]** If one or both of the forming tools 30, 31 are used for deep-drawing, a corresponding negative form (not shown) may be used together with the positive forms 305, 315.

**[0073]** In the present example, no negative forms are provided as the forming tools 30, 31 are used for thermoforming with positive forms. The production of outer and inner door leaf shells 10, 11 will be described in more detail with reference to Figs. 6A and 6B, which show cross sections of the forming tools 30, 31 cut open at planes C-C and D-D, respectively.

**[0074]** Fig. 6A shows in cross section various components of the forming tool 30 for forming outer door leaf shells 10. A heating mechanism is provided, comprising a plurality of heating elements 304 serving for heating the form block 301 and thereby for heating a thermoplas-

tic material. The heating elements may be designed as electric conductors with a high electrical resistance heating by providing an electrical resistance to an electric current. Alternatively, a hot fluid such as hot water or steam may be conducted through the heating elements 304 which for this purpose can be formed as pipes, e.g. copper pipes. When heated, the thermoplastic sheet material may be modified in its shape which is kept by the thermoplastic sheet material after subsequent cooling. The temperatures which are necessary to achieve a required flexibility depends on the specific material which is used as sheet material. Cooling may be effected passively by turning off the heating elements or actively by providing a cooling mechanism. For example, a cool fluid may be conducted through corresponding pipes. When the heating elements 304 are formed as pipes, they could be also used as cooling elements.

**[0075]** The forming tool 30 further comprises a plurality of vacuum chambers 303. A vacuum pump (not shown) for creating a negative pressure with respect to the surrounding air pressure is connected to the vacuum chambers 303 which are in fluid connection with a plurality of vacuum channels extending from the vacuum chambers 303 to the surface of the positive form 305 and possibly also to the form area 301 such that a negative pressure in the vacuum chambers 303 leads to a suction of a heated thermoplastic sheet material disposed on the forming tool 30 against the surface of the positive form 305 (and to the form area 301).

**[0076]** The surrounding edges of the sheet material to be formed may be fixed or pressed against a frame with a suitable fixture (not shown). Therein, the sheet material may or may not be allowed to slide through the fixture. The fixture may also serve to provide a closed space between the positive form 305 and the sheet material such as to allow for the creation of a negative pressure. Optionally, additional heating and/or cooling elements may be provided on the other side of the sheet material with respect to the heating elements 304 shown in Fig. 6A. Optionally, the positive form 305 and the fixture may be displaceable with respect to one another.

**[0077]** Thus, an outer door panel shell 10 may be produced by disposing a sheet material such as a plastics foil with a thickness of 2 mm or about 2 mm over the positive form 305, heating the sheet material such that it becomes flexible enough for forming, creating a negative pressure in the space between the sheet material and the positive form 305 (and optionally displace a fixture, e.g. a frame, holding the sheet material and the positive form 305 relatively towards one another) such that the sheet material lies against the positive form 305 and assumes the shape of the positive form 305, cooling the sheet material such that it becomes stiff and withdrawing the sheet material having the form of an outer door leaf shell 10 but still having a circumferential protrusion 103 which is removed in a later stage of the production.

**[0078]** Fig. 6B shows the forming tool 31 for forming inner door leaf shells 11 in cross section. As the forming

tool 30 for forming outer door leaf shells 10, the forming tool 31 for forming inner door leaf shells 11 has heating elements 314 and vacuum chambers 313. The function of the forming tool 30 for forming inner door leaf shells 11 corresponds to the function of the forming tool 30 for forming outer door leaf shells 10 so that reference is made to the description referring to Fig. 6A above also regarding Fig. 6B.

**[0079]** Fig. 7 shows a foaming tool 4 in cross section which is used for inserting a foam in the inner space 13 formed between the outer and inner door leaf shells 10, 11 after their corresponding arrangement as depicted.

**[0080]** The foaming tool 4 comprises an upper tool part 40 and a lower tool part 41 which may be displaced with respect to one another so as to allow for disposing an outer and an inner door leaf shell 10, 11 in correspondingly shaped receptacles 403, 414 formed in tool blocks 404, 415 mounted on bases 400, 410 of each of the upper and lower tool parts 40, 41.

**[0081]** When closing the foaming tool 4, a centering device 42 having opposing centering blocks 42A, 42B mounted on each of the upper and lower tool parts 40, 41 serve for a precise alignment of the upper and lower tool parts 40, 41. The centering blocks 42A, 42B may be arranged on various positions around the outer and inner door leaf shells 10, 11 located inside the foaming tool 4. Alternatively, one circumferential centering block 42A, 42B may be provided on each of the upper and lower tool parts 40, 41.

**[0082]** A circumferential seal 413 is provided in the tool block 415 of the lower tool part 41 and serves for a tight closure of the foaming tool 4. Of course, more than one seal may be provided, also seals may be provided in the upper tool part 40.

**[0083]** When the foaming tool 4 is closed as seen in Fig. 7, having an outer and an inner door leaf shell 10, 11 disposed and aligned therein, the sheet material of the outer and inner door leaf shells 10, 11 may be urged against the receptacles 403, 414 by creating a negative pressure in vacuum chambers 401, 411 of the upper and lower tool parts 40, 41 connected with the receptacles 403, 414 by means of vacuum channels not shown in Fig. 7. Then, a foam material (and or other suitable materials for at least partially filling the inner space 13) may be introduced into the inner space 13. Alternatively or in addition, the material or part of the material may be disposed on one or both of the outer and inner door leaf shells 10, 11 before forming the inner space 13 by arranging the outer and inner door leaf shells 10, 11 against each other.

**[0084]** Heating elements 402, 412 in the upper and lower tool parts 40, 41 e.g. may serve to activate or promote a foaming operation and/or harden or curing the foam material. The heating elements 402, 412 could be used for heating. Alternatively or selectively, they could also be used for cooling. Both heating and cooling could be effected e.g. electrically or by conducting a hot or cold fluid through the heating elements 402, 412. The heating

elements 402, 412 can be formed as copper pipes.

**[0085]** When the inner space 13 is filled with material, the foaming tool may again be opened for withdrawal of the door leaf device 1 thus formed. The foam material filled in the inner space 13 may serve to connect the outer and inner door leaf shells 10, 11 to one another. Alternatively or additionally, the outer and inner door leaf shells 10, 11 may also be connected to one another by other means of fastening.

**[0086]** After filling the inner space 13 with material, the outer and inner door leaf shells 10, 11 still have circumferential protrusions 103, 112 and no cutouts for forming the window opening 120.

**[0087]** As an example, the foaming tool may have a length of about 2300 mm, a width of about 1000 mm and a height of about 250 mm. However, also strongly differing sizes are possible and may e.g. depend on the size of the door leaf device 1 to be produced.

**[0088]** Fig. 8 shows in a cross-sectional view a milling fixture 5 which is configured for fixing a door leaf device 1 on a fixture block 52 arranged on a base 50 thereof. A negative pressure may be applied for fixing the door leaf device 1 to the fixture block 52 by a mechanism similar to the vacuum mechanism of the forming tools 30, 31 and the foaming tool 4. A circumferential seal 51 serves for sealing the door leaf device 1 with the fixture block 52.

**[0089]** The door leaf device 1 rests on the fixture block 52 with its outside face 16 formed by the outer door leaf shell 10. When being securely fixed by the milling fixture 5, the circumferential protrusions 103, 112 of the outer and inner door leaf shells 10, 11 may be removed by milling. Also, cutouts 150A, 150B for subsequent insertion of seals may be milled into the foam layer 15. Furthermore, also cutouts 100A, 110A (not visible in Fig. 8 but shown in Fig. 4) for forming a window opening 120 in the door leaf device 1 may be milled or cut in the door leaf device 1. Of course, also other parts of the door leaf device 1 may be worked on the milling fixture, e.g. other parts may be milled or cut, holes may be drilled and additional components may be mounted on the door leaf device 1.

**[0090]** Figs. 9A and 9B show in perspective views another embodiment of a door leaf device 1'. The door leaf device 1' according to Figs. 9A and 9B as well as its production mostly corresponds to the door leaf device 1 according to Figs. 1 to 4 and the production explained with reference to Figs. 5A to 8 so that reference is made to the corresponding description hereinabove and only those details of the door leaf device 1' according to Figs. 9A and 9B and its production are described below in which it differs from the door leaf device 1 according to Figs. 1 to 4.

**[0091]** The door leaf device 1' comprises outer and inner door leaf layers in the form of outer and inner door leaf shells 10', 11' which are made of a transparent material. In particular, the transparency of the transparent material may be such as to allow to look through it. The transparent material may be a plastics material, a poly-

mer material or glass, for example. While also the outer and inner door leaf shells 10, 11 of the door leaf device 1 according to Figs. 1 to 4 may be made of a transparent material, in contrast thereto, the outer and inner door leaf layers 10', 11' of Figs. 9A and 9B do not have cutouts for mounting a window pane. Instead, the outer and inner door leaf shells 10', 11' each comprise a window section 105, 114 which is recessed with respect to the surrounding material of the outer and inner door leaf layers 10', 11'. Alternatively, the window sections 105, 114 could of course also be flush with the adjacent surfaces or protrude therefrom.

**[0092]** The window sections 105, 114 are aligned to one another such as to form a window 12' of the door leaf device 1'. Of course, there may be provided more than one window section 105, 114 each, such as to form more than one window.

**[0093]** Because no window pane being a separate part needs to be mounted on the door leaf device 1', the latter does not have any abutment surfaces for mounting such a window pane.

**[0094]** Those areas of the outer and inner door leaf shells 10', 11', which do not form the window 12', are varnished (and could also be covered or made at least partially opaque in another way, e.g. by coating with a foil).

**[0095]** Though the outer and inner door leaf shells 10', 11' may form an inner space between each other also at the window sections 105, 114, it is preferred that this part of the inner space is not filled with a core material to maintain the transparency of the window 12'. Alternatively, the outer and inner door leaf shells 10', 11' could also contact each other at their window sections 105, 114, wherein then no inner space is formed there. The window sections 105, 114 may also be adhered or bonded to one another to increase stability and eventually to improve the optical properties of the window.

**[0096]** Since no separate window pane has to be mounted to the door leaf device 1' and no corresponding cutouts have to be introduced in the outer and inner door leaf shells 10', 11', its production is particularly simple.

**[0097]** The outer and inner door leaf shells 10', 11' each provide substantially the entire outer and inner faces 16, 17 of the door leaf device 1', respectively.

**[0098]** It is noted that the shapes of the outer and inner door leaf shells 10, 11; 10', 11' shown in the figures only serve as an example and of course also various other shapes are possible.

List of reference numerals:

**[0099]**

1, 1' door leaf device  
10, 10' outer door leaf shell  
100A-100C cutout  
101A-101D abutment surface  
102A, 102B lateral edge

|             |                            |
|-------------|----------------------------|
| 103         | circumferential protrusion |
| 104         | inner surface              |
| 105         | window section             |
| 11, 11'     | inner door leaf shell      |
| 5 110A-110C | cutout                     |
| 111A, 111B  | lateral edge               |
| 112         | circumferential protrusion |
| 113         | inner surface              |
| 114         | window section             |
| 10 12       | door window                |
| 120         | window opening             |
| 121         | window pane                |
| 13          | inner space                |
| 130A, 130B  | compartment                |
| 15 14       | seal                       |
| 15          | foam layer                 |
| 150A-150D   | cutout                     |
| 16          | outside face               |
| 17          | inside face                |
| 20 18A-18B  | gap                        |
| 2           | wagon                      |
| 20          | wagon body                 |
| 21          | window                     |
| 22,23       | door                       |
| 25 30       | forming tool               |
| 300         | base                       |
| 301         | form block                 |
| 302         | form area                  |
| 303         | vacuum chamber             |
| 30 304      | heating element            |
| 305         | positive form              |
| 31          | forming tool               |
| 310         | base                       |
| 311         | form block                 |
| 35 312      | form area                  |
| 313         | vacuum chamber             |
| 314         | heating element            |
| 315         | positive form              |
| 4           | foaming tool               |
| 40 40       | upper tool part            |
| 400         | base                       |
| 401         | vacuum chamber             |
| 402         | heating element            |
| 403         | receptacle                 |
| 45 404      | tool block                 |
| 41          | lower tool part            |
| 410         | base                       |
| 411         | vacuum chamber             |
| 412         | heating element            |
| 50 413      | seal                       |
| 414         | receptacle                 |
| 415         | tool block                 |
| 42          | centering device           |
| 42A, 42B    | centering block            |
| 55 5        | milling fixture            |
| 50          | base                       |
| 51          | seal                       |
| 52          | fixture block              |

## Claims

1. A door leaf device being configured and provided for use in a wagon (2) of a mass transportation vehicle, having an outside face (16), an inside face (17), a height and a width and comprising an outer door leaf layer (10; 10') at least partially forming the outside face (16) and an inner door leaf layer (11; 11') at least partially forming the inside face (17), the outer and inner door leaf layers (10, 11; 10', 11') being arranged with respect to one another so as to form an inner space (13) therebetween, **characterized in that** at least one of the outer and inner door leaf layers (10, 11; 10', 11') substantially extends over the height and/or the width of the door leaf device (1; 1') and is formed in one piece.
2. The door leaf device according to claim 1, **characterized in that** at least the one of the outer and inner door leaf layers (10, 11; 10', 11') is made by deep-drawing or thermoforming a planar sheet material, in particular a polymer material.
3. The door leaf device according to claim 1 or 2, **characterized in that** both the outer door leaf layer (10, 10') and the inner door leaf layer (11, 11') each substantially extend over the height and/or the width of the door leaf device (1; 1') and each are formed in one piece.
4. The door leaf device according to any of the preceding claims, **characterized in that** the inner space (13) between the outer and inner door leaf layers (10, 11; 10', 11') is at least partially filled with a core material (15).
5. The door leaf device according to claim 4, **characterized in that** the core material (15) comprises at least one of a foam material, polyurethane foam, melamine resin foam, glass fiber, a fiber-reinforced composite, a honeycomb material and a rigid foam board.
6. The door leaf device according to claim 5, **characterized in that** the core material (15) comprises a first foam material having a first hardness and a second foam material having a second hardness, the first hardness and the second hardness being different from one another.
7. The door leaf device according to any of claims 4 to 6, **characterized in that** the outer and inner door leaf layers (10, 11) and/or the core material (15) are made of a flame retardant, nonmetallic material.
8. The door leaf device according to any of the preceding claims, **characterized by** a window (12) being formed by cutouts (100A, 110A) in the outer and inner door leaf layers (10, 11).
9. The door leaf device according to any of the preceding claims, **characterized in that** at least one of the outer and inner door leaf layers (10', 11') comprises a transparent material, wherein at least a section (105, 114) of the transparent material forms a window (12') of the door leaf device (1').
10. The door leaf device according to any of the preceding claims, **characterized in that** at least the one of the outer and inner door leaf layers (10, 11; 10', 11') provides at least one edge portion (102A, 102B, 111 A, 111 B) of lateral, upper and lower edges of the door leaf device (1; 1').
11. The door leaf device according to any of the preceding claims, **characterized in that** at least one of the outer and inner door leaf layers (10, 11; 10', 11') comprises an inner surface (104, 113) at least partially facing the inner space (13) and being at least partially provided with a polymer material, a resin, epoxy and/or a fiber material such as glass fiber.
12. The door leaf device according to any of the preceding claims, **characterized in that** at least one of the outer and inner door leaf layers (10, 11; 10', 11') forms at least a partial section of the external surface of the door leaf device (1), in particular at least one of the outer and inner door leaf layers (10, 11; 10', 11') forming a surface structure and/or providing an externally visible color of at least a partial section of the external surface of the door leaf device (1).
13. The door leaf device according to any of the preceding claims, **characterized in that** at least one of the outer and inner door leaf layers (10, 11; 10', 11') is colored through and/or made of a fully tinted material.
14. A method for the production of a door leaf device being configured and provided for use in a wagon (2) of a mass transportation vehicle and having an outside face (16), an inside face (17), a height and a width, the method comprising the steps of:
  - providing an outer door leaf layer (10; 10') for at least partially forming the outside face (16) and an inner door leaf layer (11; 11') for at least partially forming the inside face (17) and
  - arranging the outer and inner door leaf layers (10, 11; 10', 11') with respect to one another so as to form an inner space (13) therebetween,**characterized by** the preceding step of:
  - forming at least one of the outer and inner door leaf layers (10, 11; 10', 11') in one piece and

such that it substantially extends over the height and/or the width of the door leaf device (1; 1').

15. The method according to claim 14, **characterized in that** at least the one of the outer and inner door leaf layers (10, 11; 10', 11') is formed in one piece by deep-drawing or thermoforming a planar sheet material. 5
16. The method according to claim 14 or 15, **characterized by** the subsequent step of introducing a foam material (15) into the inner space (13) between the outer and inner door leaf layers (10, 11; 10', 11'). 10
17. The method according to any of claims 14 to 16, **characterized by** the subsequent step of removing material of at least one of the outer and inner door leaf layers (10, 11; 10', 11') by at least one out of cutting, milling and drilling. 15  
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18. The method according to claim 17, **characterized by** arranging a window pane (121) at a window opening (120) formed by cutouts (100A, 110A) in the outer and inner door leaf layers (10, 11; 10', 11') by the step of removing material. 25
19. A door leaf device being configured and provided for use in a wagon (2) of a mass transportation vehicle, **characterized in that** the door leaf device (1; 1') is produced by a method according to any of claims 14 to 18. 30
20. A wagon (3), comprising at least one door leaf device (1; 1') according to any of claims 1 to 13 and 19. 35

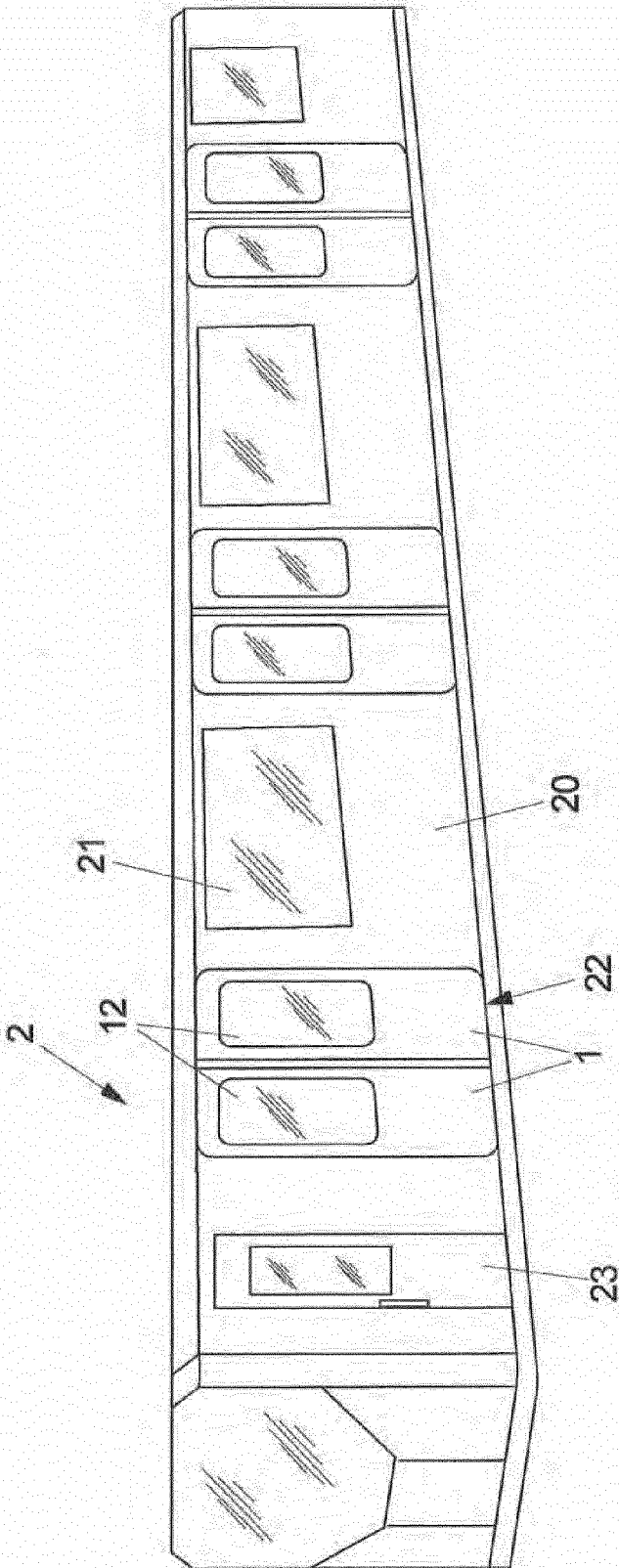
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FIG 1



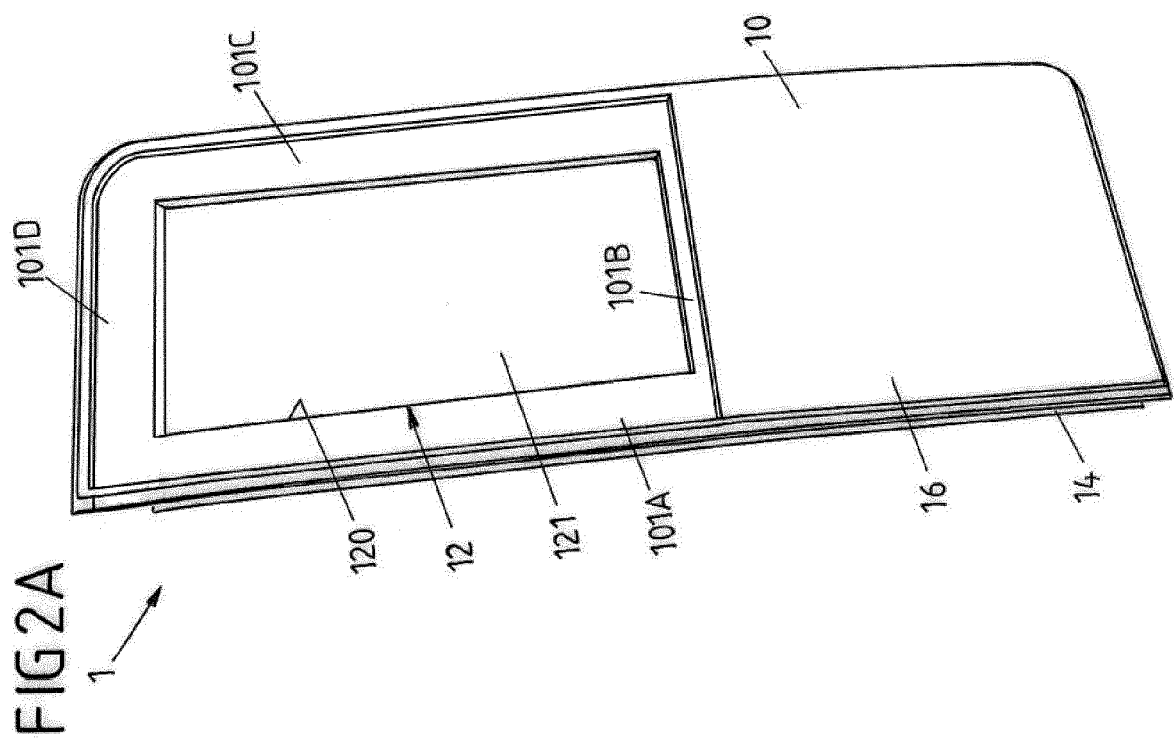
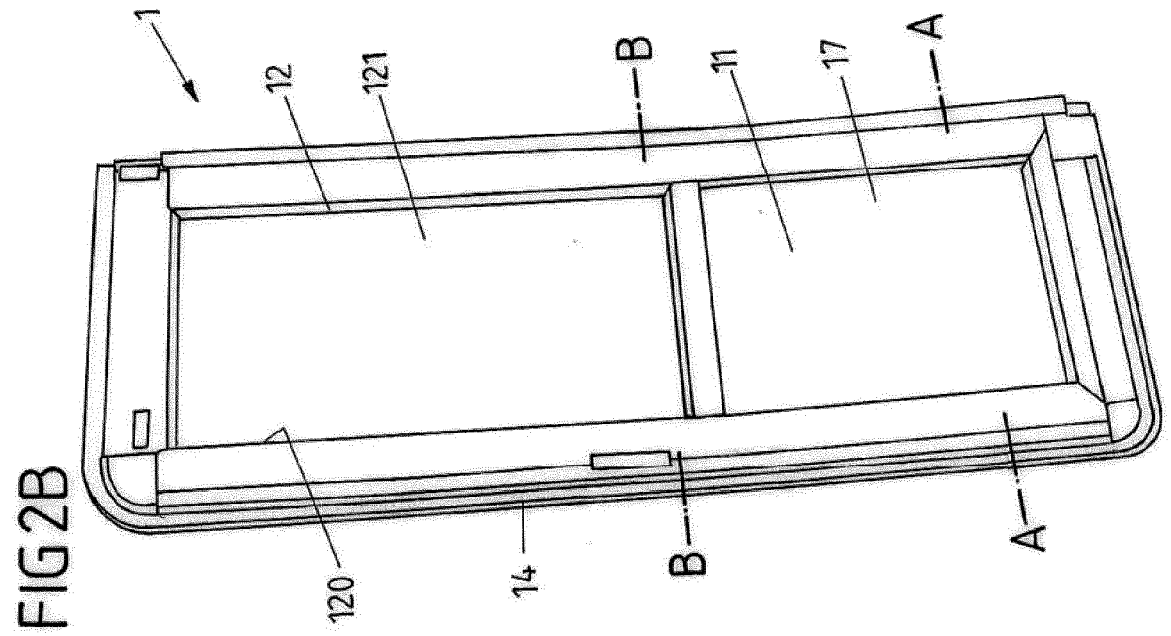


FIG 3

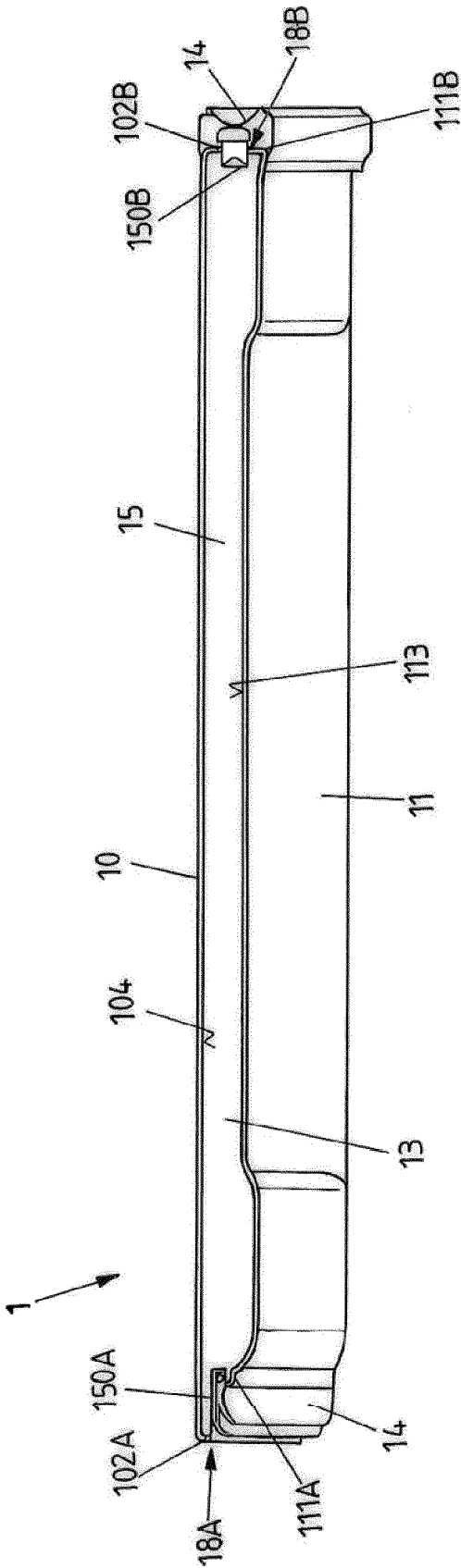
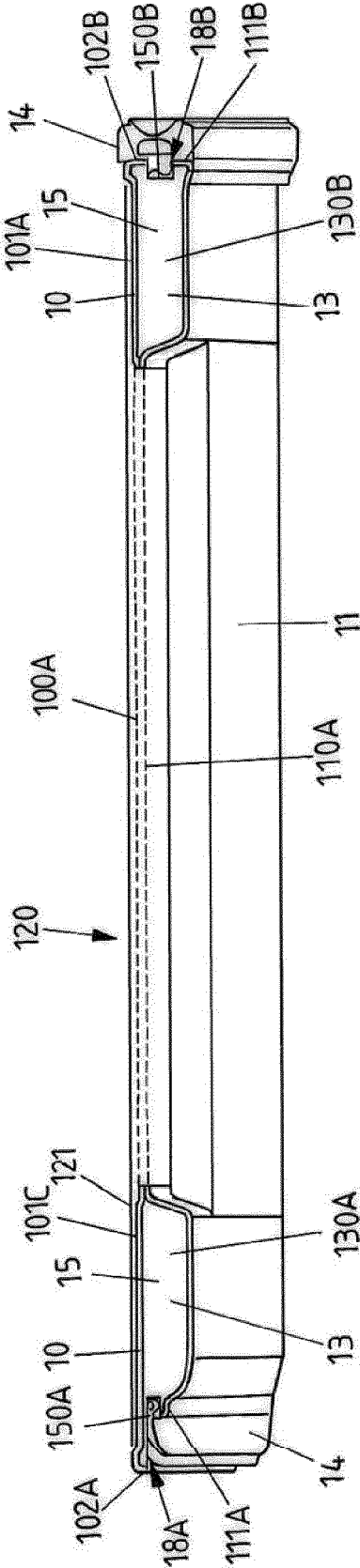


FIG 4



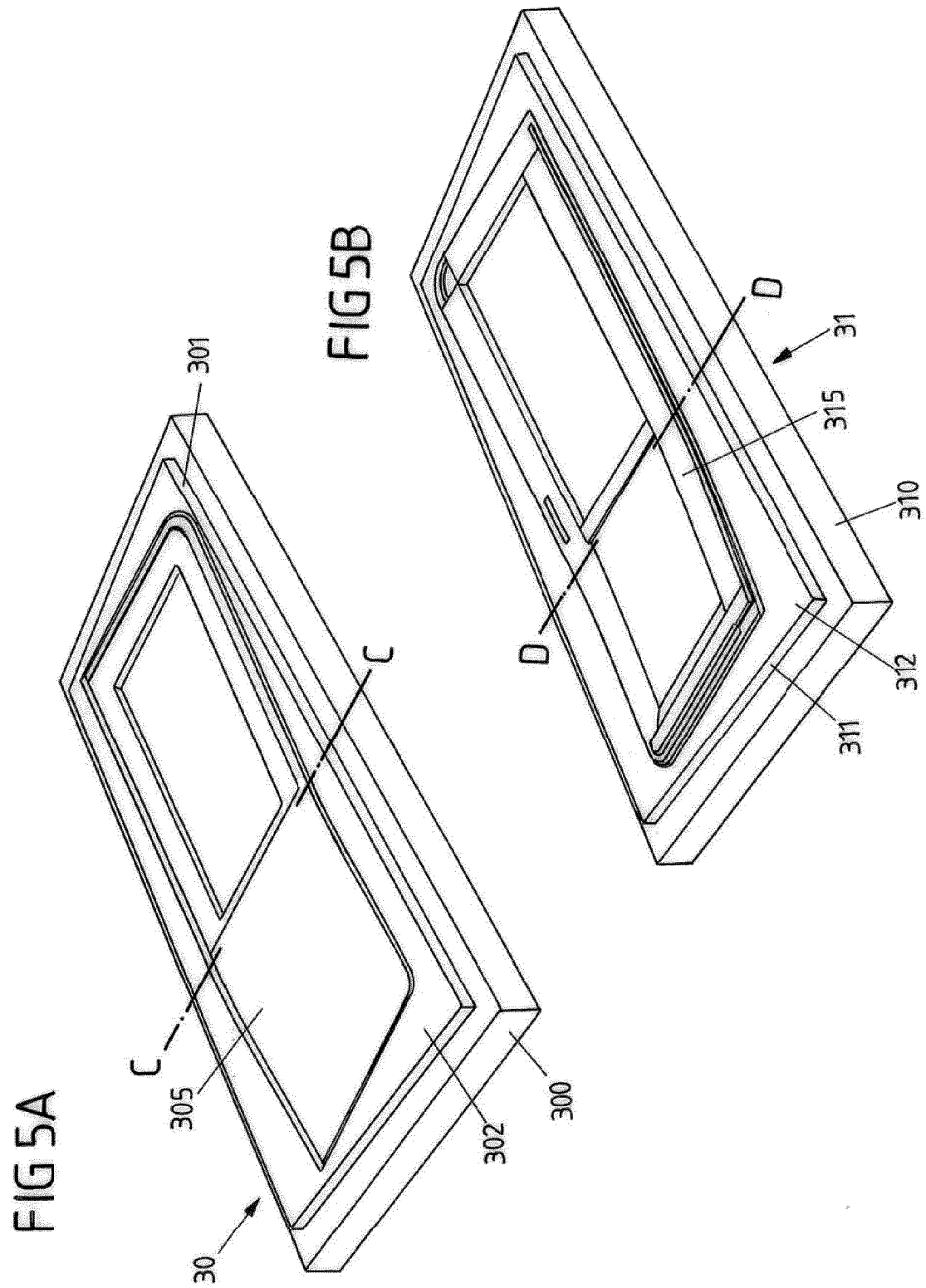


FIG 6A

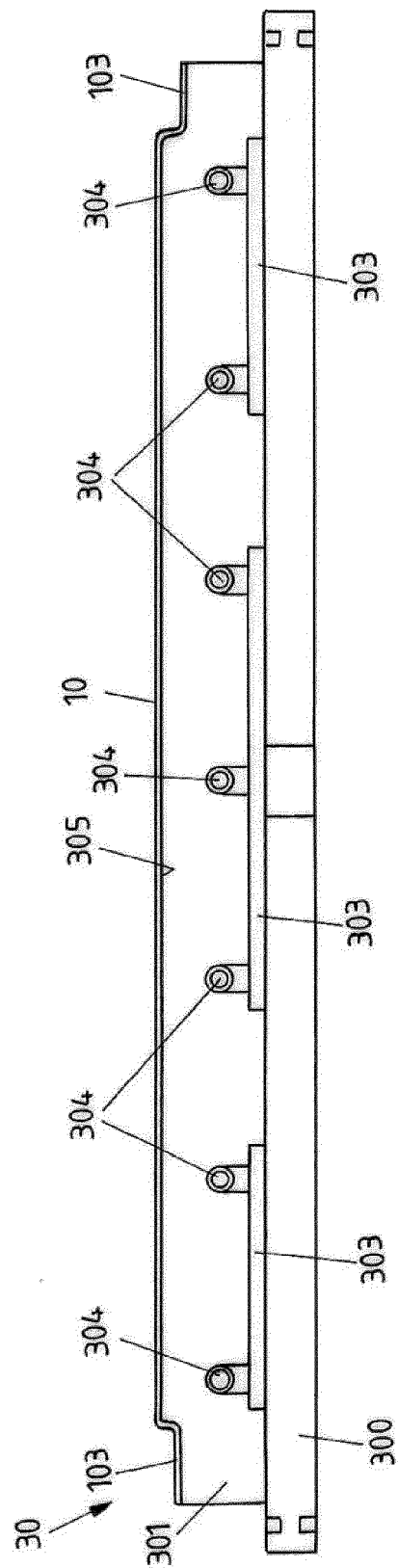


FIG 6B

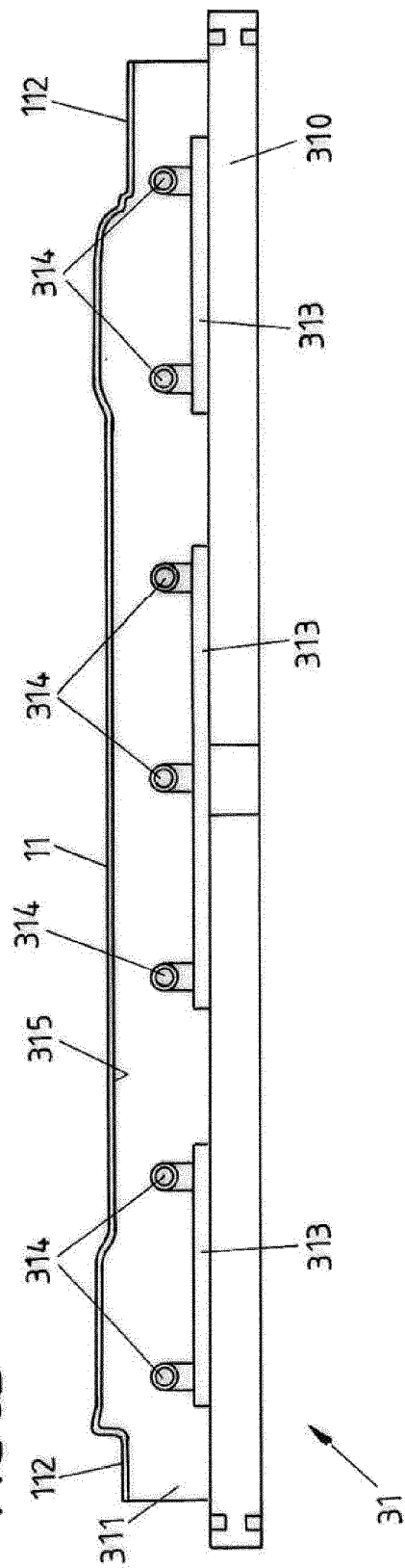
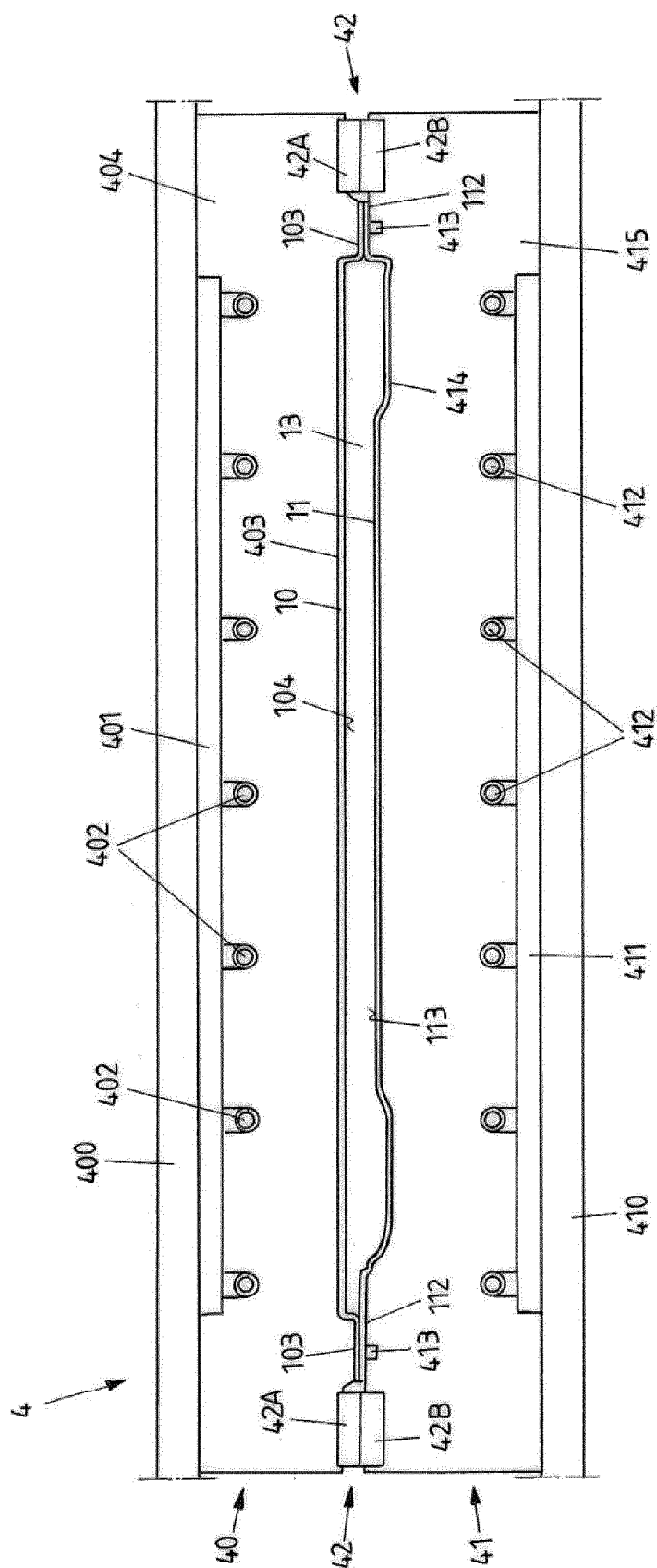
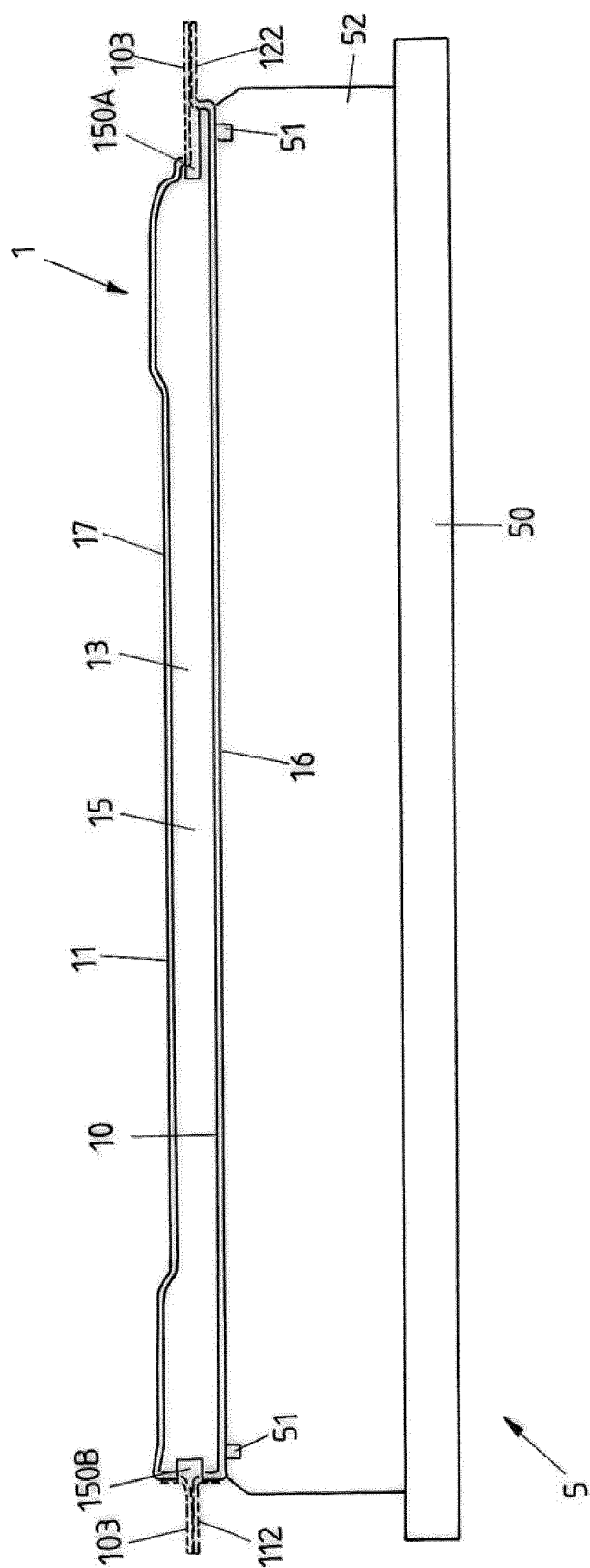
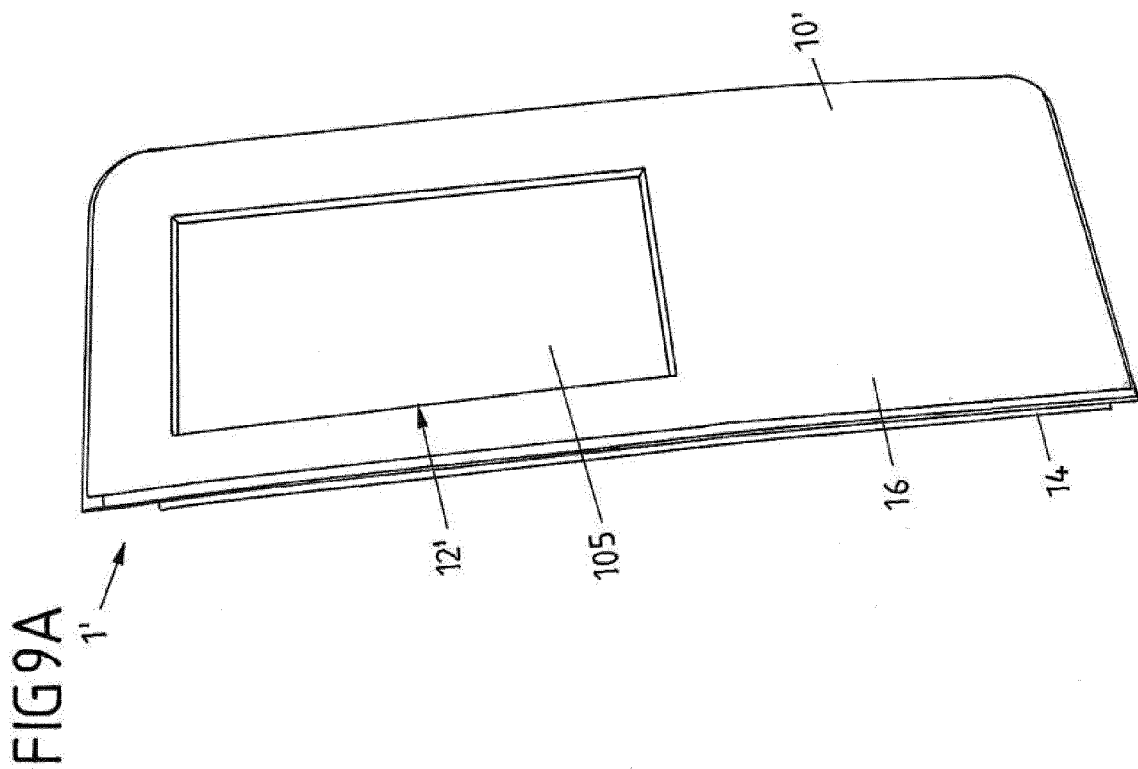
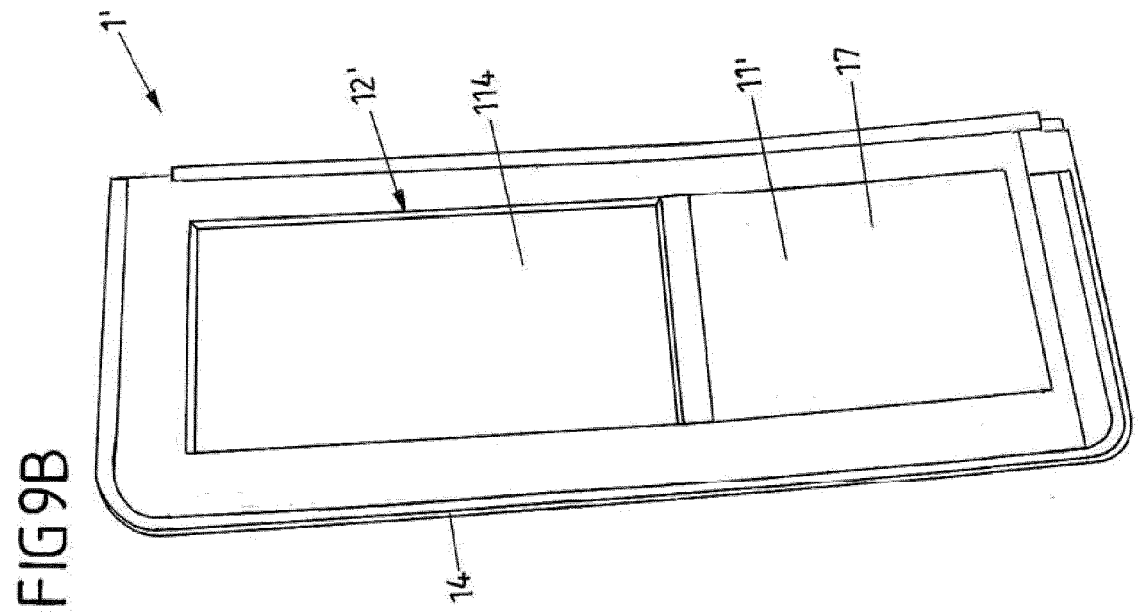


FIG 7



F/G 8







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Application Number  
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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                                                        |                                                                                                                                                                                                                                                                              |                                         |
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|                                                                                                                                                                                                                                                        |                                                                                                                                                                        |                                                                                                                                                                                                                                                                              | TECHNICAL FIELDS SEARCHED (IPC)         |
|                                                                                                                                                                                                                                                        |                                                                                                                                                                        |                                                                                                                                                                                                                                                                              | B61D                                    |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                                                        |                                                                                                                                                                                                                                                                              |                                         |
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                       |                                                                                                                                                                        | Date of completion of the search<br><b>24 February 2015</b>                                                                                                                                                                                                                  | Examiner<br><b>Schultze, Yves</b>       |
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